Maine Department of Environmental Protection
Bureau of Land & Water Quality
O&M Newsletter
July 2006
A monthly newsletter for wastewater discharge licensees, treatment facility operators, and associated persons

Index

An Introduction to Wastewater Biology

The following is taken from Environmental Training Consultants, 1994, "Activated Sludge Operations for Pulp & Paper Mills"

As each cell is produced and develops in the pattern of its parents, it must maintain and regulate the complex organization specific to it. Although the pattern and specific organization may vary from one group of microorganisms to another, the processes are much the same.

After a cell is produced, it grows. Growth means an increase in size. As the cell reaches full growth, it must maintain itself over its life span. Cell damage must be repaired, structural components replaced and food taken in and converted to useable energy. Waste materials are expelled and special substances are produced and reproductive processes are carried out. Eventually the cell dies because it can no longer maintain itself, or because it is exposed to some condition it cannot tolerate.

Molecules within a cell are in a constant state of flux. They are continually being replaced, transformed, or renewed in the process of cell maintenance. The chemical reactions that produce these changes are referred to as metabolism. In a mature cell the process of maintenance means that the whole metabolic process is in balance. That is, some molecules are broken down (catabolism) and some are formed (anabolism). Overall, the cell reaches a dynamic equilibrium where it is in steady state. Metabolism is the sum of all the catabolic and anabolic reactions.

As the cell works to maintain this steady state of equilibrium, it uses energy in many processes, such as repair, replacement, special substance production and reproduction. The need for energy is probably the single most important problem facing the cell. There are two major sources

of energy available to the cell. Energy bound up in the chemical structure of food particles can be converted to a usable form. Secondly, for some cells, the special ability to photosynthesize allows them to convert radiant energy from the sun into chemical energy which is ultimately used to build cell mass.

Chemically speaking, the substances we refer to as food are organic molecules. The term organic means that the molecule was at one time part of a living organism: plant or animal. These organic molecules are also called "biochemical" or living chemicals. Inorganic molecules, on the other hand, are mineral in nature, never having been part of a living organism.

The four main groups of biochemicals are proteins, carbohydrates, lipids, and nucleic acids. Structurally, these are very large molecules with many chemical bonds, and therefore, with a large amount of stored chemical energy. These biochemicals become available to the cell through the breakdown and decomposition of the bodies of other living organisms and from the waste products of other living organisms.

Various methods are used to get food particles into the cell, but once inside, the process is about the same. The food particles are small by this time, since they must be able to pass through the cell membrane. But they still have many chemical bonds, and thus have a large amount of energy. The food particles, more correctly molecules, travel through a maze of metabolic pathways where the energy is converted to a form and size that can be used by the cells when needed.

The process of deriving usable energy from high energy food molecules is technically called respiration. The process involves many sequential steps as the food molecule is broken apart piece by piece. The sequence is catalyzed by and controlled by and entire system of enzymes within the cell.

Enzymes are protein molecules which take an active part in all biochemical reactions, but they are not changed in the reaction. When they are present the reaction can take place. Enzymes are very specific. This is, each reaction in the cell is catalyzed by its own specific enzyme. Control of a reaction sequence is possible by the presence or absence of specific enzymes. The presence or absence of enzymes is in turn controlled by the cell nucleus.

Since all biochemical reactions are dependent upon enzymes, it is necessary to have a set of viable, fully active enzymes available. The environmental condition within which the enzymes must function is, therefore, of great importance. Not only will these conditions influence the enzyme, but through them the overall activity and viability of the entire cell is affected.

What does all this have to do with a treatment plant? Well, we depend on the bugs in the plant to remove most of the pollutants in the wastewater by consuming them during their normal metabolic reactions. This, of course, requires their enzyme systems to be fully functional. Extremes in pH, temperature, toxics and other factors which interfere with enzyme function interrupt the treatment process.

Plant operators try to control the "growth pressures" so that metabolism functions normally. A growth pressure is defined as any factor which affects the microbial community.

The most common include:

- D.O. (dissolved oxygen)
- BOD_5 (type and amount of food)
- F/M ratio (food to microorganism ratio)
- Temperature
- Nutrients (N & P)
- Toxics
- Hydraulics (detention time)

There are two important respiration processes of interest to sanitary microbiology. These are referred to as aerobic and anaerobic respiration.

Aerobic respiration is the most common and, from energy standpoint, is much more efficient. The term aerobic means "in the presence of free or dissolved oxygen". Aerobic organisms are capable of living only in the presence of free or dissolved oxygen because the respiration process requires free oxygen. The oxygen is involved in the last step of the sequence of respiration reactions. But without the oxygen the entire sequence is blocked and the cell is unable to release energy from the high-energy food molecules.

Lipids (fats and grease), carbohydrates (sugar and starch), and proteins can all be used as sources of energy in aerobic respiration. When these organic compounds are broken down in aerobic respiration, energy, water and carbon dioxide are released as end products. When respiration goes to this end point, essentially all the available energy has been released from the organic compounds.

Anaerobic respiration occurs in "the absence of free or dissolved oxygen". Oxygen, which is still required for respiration, is obtained by using oxygen bound in other compounds, such as nitrate (NO_3) and sulfate (SO_4). When organic compounds undergo anaerobic respiration, they do not break down as completely and do not release all the energy available. For this reason the anaerobic respiration process is about 15% as efficient. That is, for the same amount of organic food material, the anaerobic process could derive only 15% as much energy as the aerobic process.

The oxygen bound in some of the chemicals is more accessible for use in the anaerobic process than some of the other chemicals. The oxygen in nitrate is most readily available, followed by sulfates and phosphates. The end products that result are much more varied than in aerobic respiration, and depend upon the type of organic material being broken down and the source of bound oxygen.

Nitrogen gas (N_2), hydrogen sulfide gas (H_2S), and methane (CH_4), as well as carbon dioxide (CO_2), water and energy are among the possible end products of anaerobic respiration. Microorganisms can be classified according to the type of respiration they utilize. Aerobic organisms or aerobes use aerobic respiration. Anaerobic organisms or anaerobes use anaerobic respiration.

A third group of organisms can utilize both processes. Aerobic and anaerobic respiration, as with all types of metabolism, depends upon different enzyme systems. Aerobes have one system which uses free oxygen; anaerobes have a different enzyme system which uses chemically bound oxygen. This third group of microorganisms posses both enzyme systems, and therefore, have the faculty to use aerobic and anaerobic respiration. They are called facultative organisms.

Aerobes are sometimes called strict aerobes because they are strictly limited to life in an aerobic environment; one with free oxygen present. Likewise, anaerobes are sometimes called strict anaerobes because they are strictly limited to life in an anaerobic environment. Facultative organisms, however, can live in both environments. All organisms naturally seek conditions yielding the greatest amount of energy for their life processes. Therefore, since aerobic respiration is much more efficient than anaerobic respiration, facultative microorganisms will carry out aerobic respiration in preference to anaerobic respiration if free oxygen is available.

Don Albert

Staying Out of the Sampling Rut

Conditions at wastewater treatment facilities are always changing. As much as we all like some consistency and certainty in our lives, these changes sometimes demand that routine testing programs be modified from time to time.

Normally, facilities have well-established routines as to what, where, when and how to collect and analyze samples for process control and reporting purposes. However, operators do need to be on guard for conditions that require a change in testing procedures in order to get the information necessary for good process control and representative, accurate reporting. Under changing conditions, this information is especially important. Many types of changes may call for revisions to normal testing procedures. Industrial process or loadings can vary or influent volumes or concentrations may go up or down. Treatment processes can become upset or be taken off line. Mechanical problems may result in imbalances or overloads. All of these and many other conditions will potentially affect sampling needs.

So, what's an operator to do? First, decide how much testing is enough. Test results are important to both diagnose and document abnormal conditions and routine sampling frequencies and sometimes locations may not be adequate for unusual situations. Different, additional types of testing may be needed. Ask yourself if proposed testing will likely generate enough of the right information in the right places to properly characterize the current events. After the samples are collected, laboratory procedures may need to be modified as well.

For example, tests such as BOD or bacteria may need to have different or additional dilutions made. (As a side note, dilutions should always be set up to at least bracket limits in a permit even under routine conditions.)

Like many other things, it is important to have a plan for modified testing and laboratory procedures in advance. Take some time to think about the sort of things that might happen at your facility and how routine sampling would need to be modified in response. Consider the types, locations and frequencies of tests as well as laboratory needs. Modified testing should be continued to document conditions returning to normal. Where there have been effluent violations, DEP places considerable value on additional tests that document a problem and its resolution.

So, do a bit of planning and stay out of the sampling rut. "We always do it that way" is not the best reasoning when it comes to sampling needs under unusual conditions. Analyze the situation at hand and be adaptable. And remember that DEP's permits specify the minimum test frequency, not the optimum to fairly and accurately represent a treatment facility's operation or effluent quality under all conditions during a monitoring period.

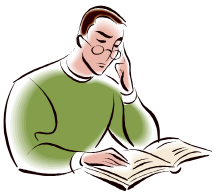
Dennis Merrill

Water Is Life

Water Is Life and Infrastructure Makes It Happen™ is a program to help communities build, maintain and improve life-sustaining water and wastewater systems. A toolkit including PowerPoint presentations, media releases and other materials is available to assist you in educating the community – visit www.WaterIsLife.Net to find these and other tools:

- ? Talking Points for a Citizen Presentation
- ? Fact Sheets
- ? Frequently Asked Questions

Don Albert



For Practice

1. A circular clarifiers treats a flow of 1,150,000 gpd with a influent suspended solids of 2,750 mg/L. The diameter is 60 feet and the depth is 12 feet. What is the solids loading?
   a. 8.2 lb/day/sq. ft.
   b. 10.7 lb/day/sq. ft.
   c. 11.1 lb/day/sq. ft.
   a. 12.6 lb/day/sq. ft.

2. A large number of filamentous bacteria in an activated sludge system may:
   a. Cause foaming in the aeration basins or clarifiers.
   b. Cause poor settling and loss of solids to the receiving waters.
   c. Result from a toxic shock to the system
   d. All of the above
3. The age of the sludge in an activated sludge facility is related to its dewaterability as follows:
   a. Older sludge is harder to dewater.
   b. Older sludge is easier to dewater.
   c. Younger sludge is easier to dewater.
   d. Sludge age has no effect on dewaterability.

4. One horsepower is equivalent to
   a. 378.2 joules
   b. 0.75 amps at a voltage of 220
   c. 746 watts
   d. 1,000 megahertz

Information wanted on potential CWSRF projects

I am in the process of developing the 2006 Intended Use Plan (IUP) to identify potential CWSRF projects to be funded from July 2006 to January, 2008. I need this information to determine the monetary need vs. available funding during this period. Those of you who may be coming to the SRF for funding should contact me. I need a project description and the estimate of funds needed. This does not commit you to borrow money from the CWSRF. It just lets me know that you may be coming to us for money. If you have not contacted me yet, please do so as soon as possible, because I am developing the IUP right now. Please call me at 287-7768 or email me at Steve.A.McLaughlin@maine.gov.

Steve McLaughlin, Engineering Manager, CWSRF

Approved Training

July 18, 2006 in Saco, ME – Uniform traffic Control & Flagging - sponsored by WPETC 1-888-621-8156 – Approved for 3.5 hours
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July 20, 2006 in Bangor, ME – Uniform traffic Control & Flagging - sponsored by WPETC 1-888-621-8156 – Approved for 3.5 hours
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July 27, 2006 in Presque Isle, ME – Uniform traffic Control & Flagging - sponsored by WPETC 1-888-621-8156 – Approved for 3.5 hours
*****
August 30 – September 27, 2006 in Caribou, ME – Class II, III & IV Water Distribution Exam Prep Course – sponsored by MRWA – (207) 729-6569 - Approved for 9.5 hours (note: wastewater operators must attend specific parts of the course for credit.)
*****
October 4, 2006 in Norway, ME – Class II Water Treatment Exam Review – sponsored by MRWA – (207) 729-6569 - Approved for 3.75 hours
*****
October 10, 2006 in Ellsworth, ME – Class III and IV Water treatment Exam Review – sponsored by MRWA – (207) 729-6569 - Approved for 2.5 hours
*****
October 11, 2006 in Belfast, ME – Class II Water Treatment Exam Review – sponsored by MRWA – (207) 729-6569 - Approved for 3.75 hours
*****
October 12, 2006 in Caribou, ME – Class III and IV Water treatment Exam Review – sponsored by MRWA – (207) 729-6569 - Approved for 2.5 hours
*****
October 17, 2006 in Easton, ME – Simplifying your Water/Wastewater Process Monitoring – sponsored by MRWA – (207) 729-6569 - Approved for 5.0 hours
*****
October 18, 2006 in Caribou, ME – Verifying your Water/Wastewater Treatment Process – sponsored by MRWA – (207) 729-6569 - Approved for 4.0 hours
*****
October 19, 2006 in Kittery, ME – Simplifying your Water/Wastewater Process Monitoring – sponsored by MRWA – (207) 729-6569 - Approved for 5.0 hours
*****
October 20, 2006 in York, ME – Verifying your Water/Wastewater Treatment Process – sponsored by MRWA – (207) 729-6569 - Approved for 4.0 hours
*****
October 26, 2006 in Dixfield, ME – Work Zone Traffic Control – sponsored by MRWA – (207) 729-6569 - Approved for 5.5 hours

Note: JETCC stands for Joint Environmental Training Coordinating Committee
MRWA stands for Maine Rural Water Association
MWWCA stands for Maine Wastewater Control Association
NEIWPCC stands for New England Interstate Water Pollution Control Commission
WPETC stands for Wright Pierce Environmental Training Center.

10th Biannual North Country Convention to be held in November

The biannual two-day training conference for operators in Northern Maine will be held this year on November 1st and 2nd in Presque Isle. As usual, 12 or more hours of approved training on a variety of topics will be presented over the two days. The North Country Convention has always been well attended by operators from the northern part of the state. It offers not only an opportunity to attend training sessions but also to meet with product vendors and exchange ideas with each other. For more information about the North Country Convention, contact JETCC at 253-8020.

Answers to *For Practice:*

1. c Solids to the clarifier = flow ? MLSS ? 8.34 = 1.15 ? 2750 ? 8.34 = 26,375 pounds/day
   Solids loading = solids to the clarifier ? clarifier area = 26,375 ? (55 ? 55 ? 0.785) = 11.1 lb/day/sq.ft.
2. d Filamentous bacteria like *Nocardia* can cause severe foaming throughout the system.
   Many filamentous bacteria cause bulking sludge, which settles poorly.
   Toxic shocks to the system can cause conditions that select for filamentous bacteria over floc-formers.
3. b Older sludges are more oxidized and therefore more dense making them easier to dewater.
4. c I Horsepower id equivalent to 746 watts or 0.746 kilowatts.